

CDFA PD/GWSS Research Program



Summary of PD/GWSS Research Scientific Review:

*Where are we with research efforts?
How do we accelerate progress?*



December 2007

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Brief Background



- Seven year collaboration
 - Industry, Scientific Community and Government Agencies
- Expectation
 - Funding and scientific efforts will provide tools and technologies against Pierce's disease
- Fairly unique relationship
 - Significant long-term funding contributions
 - Intensive & focused research efforts against a specific need

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Research Program History



The California winegrowers have contributed through the annual statewide assessment

- Approx. \$15 million in support of public sector research projects solicited by the CDFA PD/GWSS Competitive Grant Program from 2003-07

State and Federal support of PD/GWSS Research and Control Programs as well

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Research Funding History



Funding Source	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	Total by Source
CDFA			\$19,000	\$973,688	\$3,086,870	\$4,102,045	\$3,099,055	\$1,959,290	\$13,239,948
PD/GWSS									
CDFA-AB1232		\$680,901	\$680,836						\$1,361,737
CDFA-PDCP	\$747,399	\$102,807	\$73,296	\$79,532					\$1,003,034
UC PD Program			\$1,498,819	\$1,394,721	\$1,640,209	\$2,105,906	\$2,095,127		\$8,734,782
USDA-APHIS		\$2,182,843	\$1,618,811	\$1,261,234	\$410,687	\$480,705	\$402,336		\$6,356,616
USDA-Texas						\$272,727	\$1,087,531		\$1,360,258
ARS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Total by Year	\$747,399	\$2,966,551	\$3,890,762	\$3,709,175	\$5,137,766	\$6,961,383	\$6,684,049	\$1,959,290	\$32,056,375

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Assessing Research Progress



- Early scientific efforts (up to 2004) reviewed by National Academy of Sciences (NAS)
- NAS report published in 2004
 - Provided historical background on the disease and its insect vectors
 - Assessed the research completed at the time of the review
 - Set forth a broad list of PD research priorities to be targeted for subsequent research and funding activities

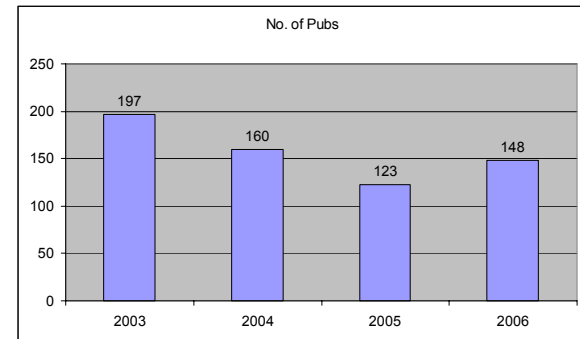
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Research Activities Continue



Considerable research effort has occurred toward finding solutions to PD since the 2004 NAS report—

Where are we now?



RSAP Report, August 2007

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Research Progress Update



- In 2006, the CDFA PD/GWSS Board requested a thorough independent scientific review, assessment and interpretation of all recent PD/GWSS research efforts and potential outcomes
- Scientific efforts reviewed within the context of:
 - The remaining three-year funding time limit (grape levy)
 - Recommendations put forward by the 2004 NAS report

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Research Scientific Advisory Panel (RSAP)



- RSAP appointed by the Secretary of California Department of Food and Agriculture
 - 6 independent scientists
 - Relevant expertise and experience
- The research review and assessment was completed in May 2007 and the report published in August of 2007
 - http://www.cdfa.ca.gov/pdcp/Documents/RSAP_Final_Report_08302007.pdf

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RSAP Members



Adam Bogdanove



Mike Davis



Greg Loeb



Roger Innes



Dan Sumner



George Sundin

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Goals of the RSAP



Evaluate progress made by PD/GWSS research program 2003-present:

- Summarize areas of significant progress
- Identify research tracks that hold the most promise
- Examine potential barriers and determine gaps
- Make recommendations for next steps

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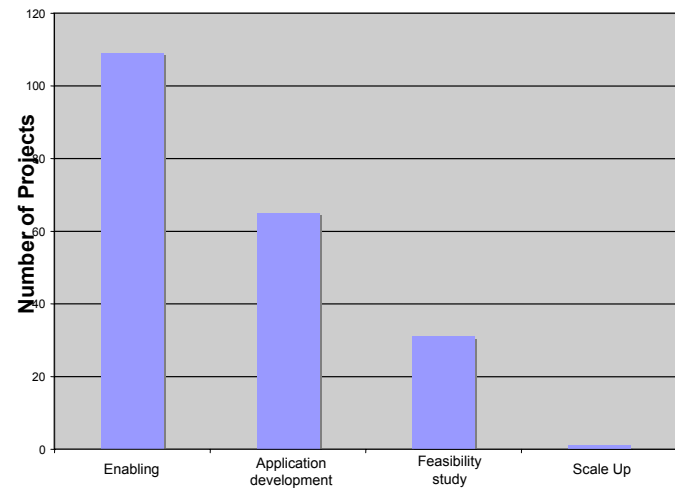
Approach



- Create a searchable database to enable efficient access to project information
- Have PI's enter succinct project summaries (http://rice.pipra.org/pd/database/report_project.php?project_id=95)
- Read project summaries (146 in total!) and categorize projects by pipeline stage, time to application, and overall progress toward a PD/GWSS solution, and alignment with National Academy recommendations
- Identify research tracks (combinations of projects) with most promise for providing a control strategy, and gaps in current research program that need to be filled
- Meet to discuss above and develop a consensus
- Next step: bring in additional expertise to evaluate non-science barriers to implementation of promising control strategies

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Research Pipeline

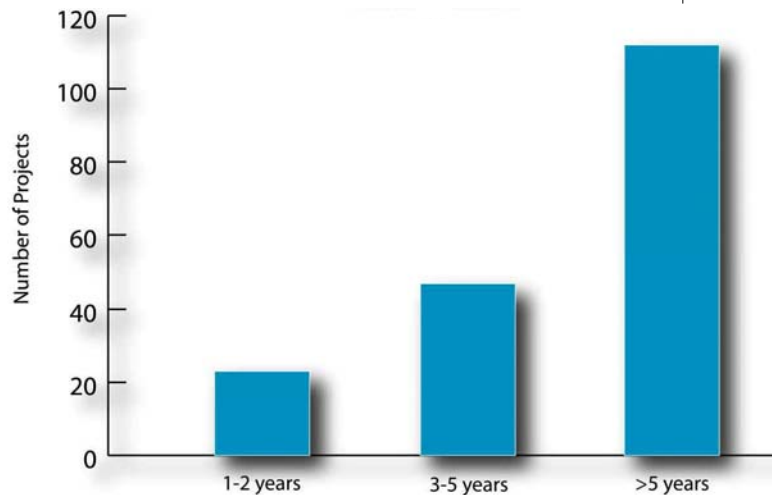


RSAP Report, August 2007

Research Pipeline Stage

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Time to application



RSAP Report, August 2007

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Areas of Significant Progress



- Identification of *Xylella fastidiosa* genes that mediate virulence on grape (polygalacturonase, *TolC*, type I and type IV pili, *Dsf*)
- Development of strain-specific genetic markers (enables tracking sources of *Xf* that cause PD outbreaks)
- Potential for using transgenic root stocks in combination with non-transgenic scions
- Understanding the habits and movements of GWSS
- Insecticidal-based control of GWSS (area-wide control programs)
- Managing GWSS with insect parasitoids
- Grape breeding for resistance/mapping PD resistance genes in grapes
- Grape genomics (gene discovery and gene expression analysis) to better understand and combat the disease

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Examples of Recent Progress



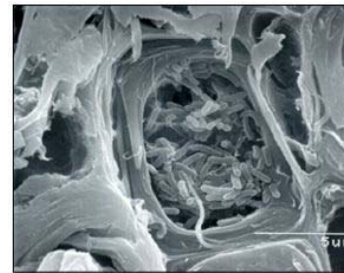
PD bacterial genes that control disease infection, spread, and severity in grape

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Example 1: Diffusible Signal Factor (Dsf)



...Selected technology *"Management of Pierce's Disease of Grape by Interfering with Cell-Cell Communication of Xf"* lead by Steven Lindow (UC Berkeley)



- PD virulence is partially attributed to biofilm production

- PD produces a diffusible-signal-factor (DSF) that regulates biofilm production.

Delicate balance of DSF Concentration:

$\uparrow[\text{DSF}] = \downarrow[\text{PD}] \text{ \& } \downarrow\text{Transmission}$
 $\downarrow[\text{DSF}] = \downarrow\text{Transmission}$



- Up or down regulation of DSF results in decrease of Transmission/PD

1 Dow, J.M. "Xylella genomics and bacterial pathogenicity to plants." Yeast 17(2000): 263-171. 2 Newman, K.L. "Cell-Cell Signaling Controls Xylella fastidiosa Interactions with Both Insects and plants." PNAS 101(2004): 1737-1742. 3 Lindow, S.E. "Management of PD of Grape by Interfering with Cell-Cell communication in Xf." PD Research Symposium Proceedings (2006): 15-16

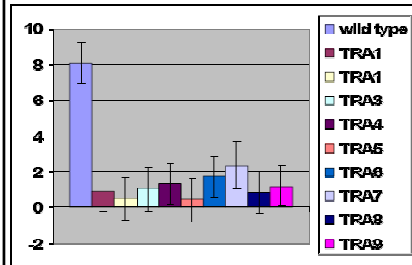
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Multiple Application Strategies



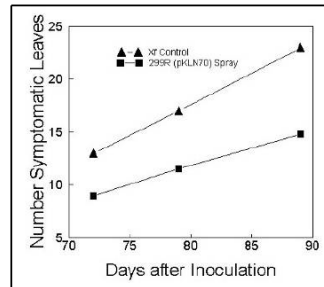
I. DSF gene put into Grape Rootstocks

GE grape plant that over-expresses DSF exhibit a reduction in disease transmission and onset of symptoms



II. Topical Application of GE bacteria expressing DSF

Spray grape plants with GM endophytes designed to over-express or degrade DSF (tested- *E. coli*, *E. herbicola*)



III. Aerosol Topical Application of Purified DSF

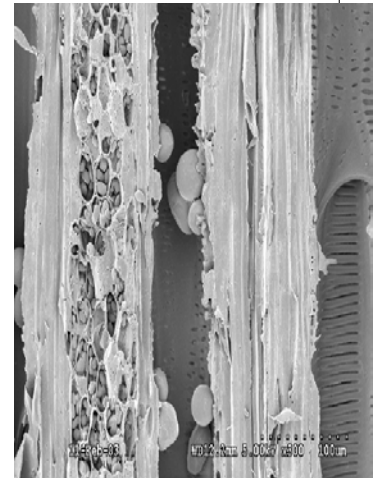
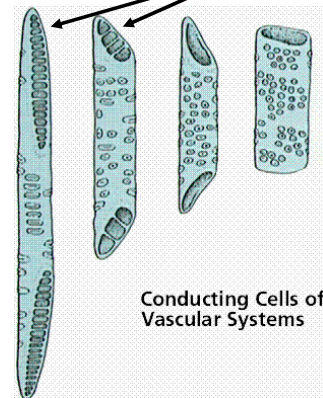
Source: Lindow, S.; Chatterjee, S.; Purcell, A. Pierce's Disease Research Symposium Proceedings 2006, pg. 181-2

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Example 2: Polygalacturonase (PG)



PG Enzyme helps PD spread throughout the plant



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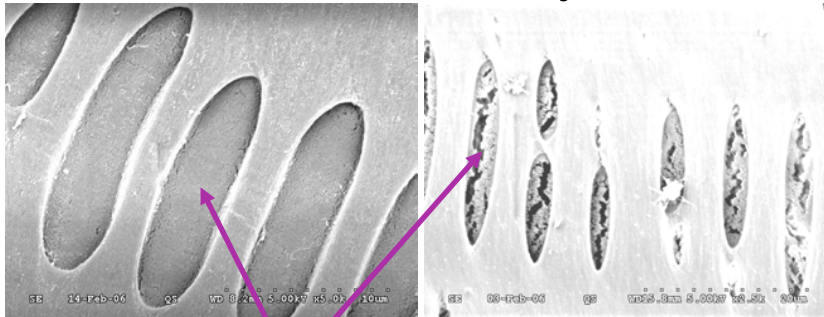
PG Enzyme Breaks Down Barriers Between Vascular Elements



PD produces an enzyme that allows it to breakdown polysaccharide barriers between xylem vessels and spread throughout the plant

Control

Enzyme treated



Xylem Vessels (face-on view)

Source: Labavitch, Dandekar & Kirkpatrick Team

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“Knocking out” PG in Gene in *Xf* Affects Disease Severity



Wild Type *PD*

PG (-) mutant *PD*

H₂O control

13 weeks post-inoculation

Source: Labavitch, Dandekar & Kirkpatrick Team

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18 Weeks After Infection



Wild Type *PD*



PG (-) *PD*

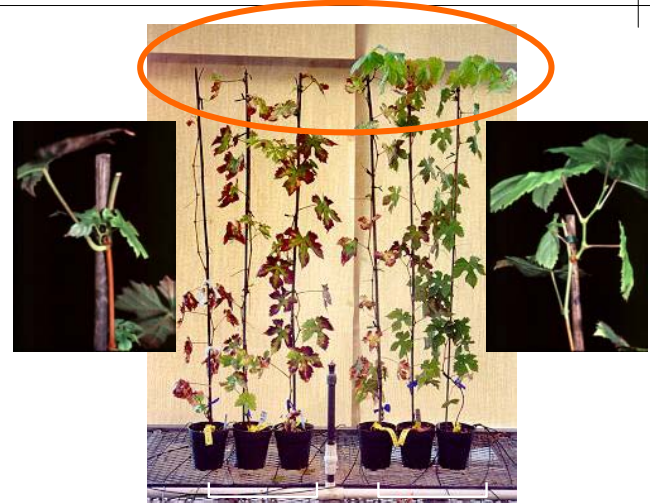


H₂O control

Source: Labavitch, Dandekar & Kirkpatrick Team

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PGIP Gene Inserted in Grape Shows Reduced PD Symptoms



Source: Labavitch, Dandekar & Kirkpatrick Team

Controls

Grape + PGIP

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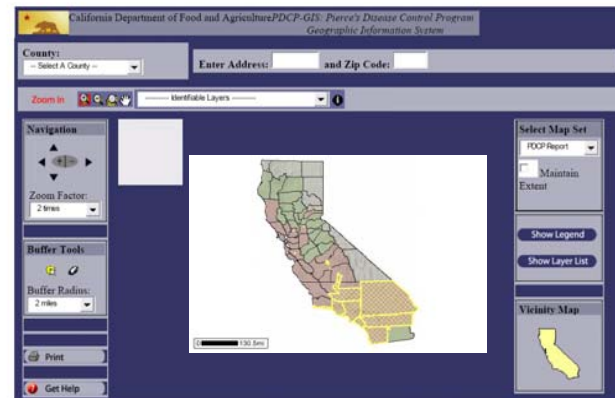
Examples of Recent Progress



- *Understanding the habits and movements of GWSS*

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Geographic Information System (GIS)



Data on GWSS populations, crop locations, parasitoid releases and insecticide treatments loaded into GIS database

Impact of environmental and biological factors on GWSS movement, feeding and reproduction

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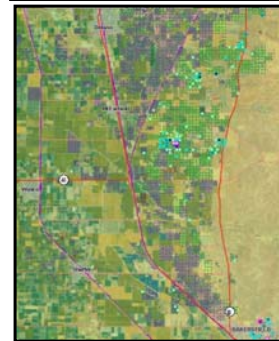
Examples of Recent Progress



*Insecticidal-based control of GWSS
(area-wide control programs)*

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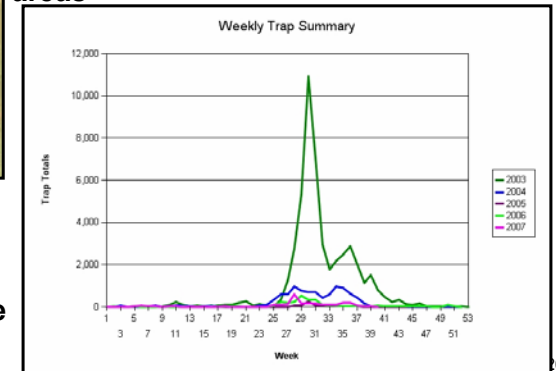
GWSS Spread Currently Contained



- Partnership with grape and citrus growers
- Strategic insecticide applications

Source: USDA APHIS

- USDA-APHIS & CDFA PD Control Program
- Comprehensive program for monitoring GWSS populations in key areas



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Examples of Recent Progress



Managing GWSS with insect parasitoids

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GWSS Egg Parasitoids Hold Promise: *Recent Advances*



- New molecular diagnostic tools
- Better identification keys for adult insects

Improved speed and accuracy in identifying species

Current Applications—

- Reduce contamination in rearing facilities
- Evaluate the success of field releases

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Examples of Recent Progress



*Grape breeding for resistance/mapping
PD resistance genes in grapes*

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PD Resistance Gene (*PDR1*) Found in Wild Grape



Photo Source: Wine Business Monthly, 4/15/2007

- Found by the Walker Lab
- Isolated from *Vitis arizonica*

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Research Gaps Identified by the RSAP

Areas of work that should be addressed to accelerate research progress

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Lack of Economic Research

Need an assessment of

- Commercial impact of PD/GWSS
- Current control measures
- Commercial viability of proposed control strategies

Information needed to validate impact, investment and potential return

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Information Gaps in Current GIS System



- Need to integrate additional data sets into GIS to improve utility of the system
 - GWSS population density info, Xylella genotype/strain distribution, PD distribution, vine replacement due to PD, crop information, temperature and geographical info
- Overlapping these additional details will allow researchers to more directly address the source of Xf strains causing PD outbreaks, and determine how it is being vectored

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Additional Gaps



- Need to Enhance Data Access and Sharing
 - Quicker access to new data and developments
 - Increase sharing of gene discovery data
- More efficient parasitoid rearing methods
 - Time- and labor-intensive
 - Better means to mass produce GWSS eggs or suitable alternative
- Extension/Education Outreach
 - Update current management recommendations
 - Enhance current extension tools
- Need more effort in resistance breeding
 - Possibly multiple sources of PD resistance genes in wild species
 - Currently one gene isolated from one wild species by one laboratory

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Current Activities

Work underway to address RSAP
Recommendations

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New Research Priorities of Next Research Grant Cycle

The RSAP recommendations for biological research priorities are being incorporated into the next UC/CDFA research grant funding cycle

- RSAP research priorities and recommendations integrated into the RFP language
- RSAP research funding priority list included in UC/CDFA joint research funding program

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Addressing Identified Gaps



- Economic Research

- CDFA PD/GWSS Research Program will be accepting economic research proposals this year
- RFP includes a separate section for economic research priorities and ad-hoc proposal review process

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The screenshot shows a web browser window titled "PIPRA Database - Mozilla Firefox". The address bar displays "http://bd.ppra.org/database/cdfa-demo.html". The page features a header with the PIPRA logo and the text "Pierce's Disease Research & Impact Database". Below the header, the form is titled "CDFA Demo Report Submission Form". The form includes several input fields and dropdown menus:

- Project Leader Name ***: Fields for Title, First, Last, and Suffix.
- Collaborators Names**: A text input field.
- Email ***: A text input field.
- Name of Institution and Address ***: Fields for Street Address, Address Line 2, City, State / Province / Region (dropdown), and Postal / Zip Code.
- Funding Source ***: A dropdown menu with "CDFA PD/GWSS Board" selected.
- Topic Area ***: A dropdown menu with "Vector Biology and Ecology" selected.
- Reporting Period**: A section with the text "The results reported here are from work conducted between the following dates:" and two date pickers for "Reporting period start date" and "Reporting period end date".

On the left side of the form, there is a sidebar with links: "About this Database", "Documents", "Advisory Panel", "Contact Us", "Login", and "Logout". Below these links are logos for "cdfa" (California Department of Food & Agriculture) and "PD/GWSS BOARD".

Addressing Gaps (cont.)



Enhancement of Geographic Information System

- CDFA a potential lead in partnership with research community
- Preliminary discussion underway to overlay additional datasets
- Feasibility test with a small scale project

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Addressing Intellectual Property and Regulatory Issues



- Partnership with PIPRA to examine key research targets
- Development of a process to proactively address potential hurdles
- Accelerate application of innovative strategies to sustainably manage PD/GWSS

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To Summarize



- Significant research progress in last 4 years
- The majority of the work underway will take time to complete
- Key research areas have been targeted for focused efforts going forward
- Key gaps in economic data and extension components should be addressed
- RSAP recommendations will play a key role in setting research and funding priorities in the coming year

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http://www.cdfa.ca.gov/pdcp/Documents/RSAP_Final_Report_08302007.pdf



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